ARGUS EXPLORATION COMPANY
A Research Subsidiary of
Cyprus Mines Corporation
4120 Birch Street, Suite 108
Newport Beach, California 92660
Telephone (714) 833-3081

11 May 1973

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

Attention: NASA Scientific & Technical Information Facility
ERTS Contracting Officer, Code 245 GSFC
ERTS Technical Officer, Code 430, GSFC
ERTS Project Scientist, Code 650, GSFC
ERTS Scientific Monitor, Code 650, GSFC
J.H. Boeckel, Code 430, GSFC (2 cc.)

Subject: Type I Progress Report, 1 March through 30 April 1973
Proposal - A Reconnaissance Space Sensing Investigation of Crustal Structure for a Strip from the Eastern Sierra Nevada to the Colorado Plateau, dated April 1971.

Reference: Proposal Control No. SR 103
GSFC Principal Investigator ID PRO 15
ERTS-A Contract NAS5-21809, Ira C. Bechtold, P.I.

Gentlemen:

In accordance with Article II, Item 3, and Paragraph 3.1 of the referenced contract, we hereby report the status of our ERTS-1 investigation.

I. Contract Objectives:

A. Analysis, interpretation and evaluation of ERTS-1 data for application to study of regional crustal structure.

B. Comparison and evaluation of selected available remote sensing techniques, including Apollo-9, X-15 and U-2 photography.

C. Field Investigations to confirm interpretation studies and evaluate significance and practical applications of geologic phenomena visible in ERTS imagery.

II. Summary of Work Performed:

A. Data Handling:

Data filing systems have been continued for ERTS-1 and other imagery.

Ground track maps for X-15 flights have been obtained for use with photography when received.

B. Literature Research:

New literature research and indexing have been accomplished through the acquisition of complete papers and abstracts of work of others as well as new journals and text books. As announcements appear in "NASA Earth Resources Program, Weekly Abstracts" copies of reports related to our project have been secured either from the authors or NTIS.

Data sources include ReDaf, NASA-MSC; WESRAC, University of Southern California; EROS, Sioux Falls, South Dakota; Pomona College; U.S. Geological Survey; Authors.

C. Scientific Communications and Correspondence:

Cooperative efforts with the University of Southern California, Engineering Department, Professor William Pratt, have continued. However, the computer compatible tape which was received was of the precision type, which was not the most useful for radiometric studies. After discussion with Mr. Ed Crump, this tape was returned and a bulk tape was sent to replace it. This has been received but the exchange delayed active work on use of the tape as indicated in the report of 15 March 1973. An appointment with Professor Pratt on May 11 will initiate this work.

Contact has been maintained with Mr. Clinton Johnson, NASA TU Officer, Edwards Air Force Base, California, in connection with the receipt and inspection of X-15 photography. So far no definite date has been set for its delivery to Edwards.

Another meeting with Mr. Phil Lohman of Hughes has resulted in comparison of color compositing techniques and exchange of ideas as to better methods of reproduction.

Mr. Ralph Yeaman of Hughes Aircraft Company in Fullerton was also a visitor in connection with our cooperative efforts.

Cooperative efforts have been carried out with Mr. H. R. Gross of McDonnell Douglas in connection with application of their UV laser fluorescence method of mineral and rock identification of the Wrightwood Fan which we have studied. We have supplied him with complete ERTS imagery including 70mm positives for all channels, 9 x 9 inch black and white prints, a color composite, our mineral samples, and thinsection slides with summaries of our petrographic studies. This is of interest because these rocks exhibit a very high ferric to ferrous ratio which is the direct opposite of the situation in moon rocks. Further cooperative work is anticipated.

Dr. Floyd Sabins of Chevron Research has visited our facility and we have inspected the equipment and work being done at his laboratory. We have exchanged methods of producing color composites and he has used our additive color viewer for securing 35mm slides. Slides from our paper given at the ERTS Symposium, March 5 to 9, 1973, were used by Dr. Sabins in his lecture course on remote sensing at the University of Southern California. He is providing us with computer read-out data from Chevron's program on earthquake epicenters in the vicinity of our test area.

Upon request of Mr. J. Wong of the Department of Water Resources of the State of California, ERTS imagery identifications were supplied for his use in preparing a color composite mosaic for the State of California. This relationship is continuing with an effort on our part to supply the information desired.

A group of individuals including Mr. B.W. Kuebler, Mr. D.C. Williams, Mr. D.G. Wilder, and Mr. L.T. Sanchez from the City of Los Angeles Department of Water and Power visited our facility and were thoroughly acquainted with the methods used by us in handling ERTS-1 imagery and the procedures used in making color composites. They were also provided with complete information as to sources of imagery and other background which would permit them to utilize this data in their work. They learned of our work through a talk given by Mr. Robert Fox (see below).

Dr. James R. Johnson, President, and Messrs. J. Palley and D. Narver of the engineering firm of Holmes & Narver, Inc. visited our facility and were very much interested in the ERTS project and its possible use in their activities. They were thoroughly briefed in the methods by which ERTS data is secured and the procedures by which we handle it to accomplish correlation with geologic features both in mineral exploration and engineering geology applications.

Dr. Richard Tibby, Director, Catalina Marine Science Center, University of Southern California, has been consulting with us as to the possible application of ERTS imagery and other remote sensing data to oceanographic and west coast problems. In particular he is interested in the use of ultra-violet identification of both naturally occurring substances and pollutants in the coastal areas of southern California. It is possible that he may suggest a project involving the use of the data we have discussed.

Mr. Robert Fox, consulting engineering geologist, has been supplied with a set of slides and special 35mm slides taken from the screen of our viewer for use in a talk which he prepared for the Southern California Water Users Association, in which he featured data from ERTS, giving credit to NASA and Argus.

Correspondence has been conducted with Dr. Fred Fischer of United States Geological Survey, Menlo Park, in connection with seismic data for southern Nevada. Also, he was sent a copy of our report on recent faults cutting alluvium along the Colorado River from Lake Mead to Needles.

Professor David Cummings of Occidental College utilized our file of SLAR film to study the area in the San Gabriel Mountains in which he has been investigating large anorthosite deposits. He also used our ERTS-1 imagery over that area, as well as the large color composites which we have made in our research on color printing techniques.

Numerous individuals have requested copies of our reports and special papers, most of which have been supplied as Xerox copies.

D. Image Enhancement Analysis:

We have continued experimentation on enhancement of ERTS-1 MSS imagery, X-15 and U-2 photography, and SLAR imagery over key subareas of the project test site. Enhancement methods include use of a Ronche grating, a Fresnel lens, and photographic edge enhancement techniques described in our Type II report of January, 1973.

Additive color viewing of ERTS-1 MSS imagery is used as a standard analysis procedure. However, for detailed work, we are placing emphasis on production of high resolution color composites. Excellent results are being achieved in cooperation with Wally MacGalliard using a method of sequential exposure printing. Once proper color balance is achieved on a master internegative, positive color prints can be produced inexpensively at any required scale.

E. Imagery Comparison and Evaluation:

NDPF image reproduction quality is still an inconvenience for effecient use of the ERTS data. In general we find the 9 x 9 inch positive transparencies to be superior to the 70mm format in image sharpness and quality.

F. Geologic Field Reconnaissance and Mapping:

Between March 9 and 12 inclusive, a field trip was made throughout the eastern side of our ERTS test area for the purpose of acquainting Mr. Richard Underwood of Johnson Spacecraft Center with the area from Parker Dam northward through the Oatman area, Black Mountains, Cerbat Mountains, the western side of the Colorado River, and the southern Lake Mead area. Mr. Underwood has been very much interested in the ERTS project and especially our application of Apollo photography and other remote sensing imagery supplied by Johnson Spacecraft Center. In this connection he has contributed significantly to the ground truth studies.

In ERTS image 5 November 1972, Orbit 1464 1105-17443, a possible lineament has been noticed which trends northwest-southeast, starting west of Needles and continuing southeastward into Arizona south of Salome. Reconnaissance field investigations have been conducted at various points along this structure, including areas west of Lake Havasu, the gorge of the Colorado River southeast of Lake Havasu to Parker Dam (which seems to align with the lineament along a fault south and east of the confluence of the Colorado and Bill Williams Rivers), Laramide intrusives north of Salome, and other features which indicate that this may constitute a massive fracture zone along which many geologic features have developed. The nature of the lineament has not been established, but further studies are intended.

Additional work was done in the field along the Colorado River northward from Parker Dam to Topock and in the Oatman district. The area from Oatman district to Kingman was also studied.

In the course of this work on the eastern side of the test area, a visit was made to the office of the Arizona Regional Ecological Test Site at USGS in Phoenix. The meetings were held with Messrs. Herbert Shumann and Henry Sanger. U-2 film data and ERTS imagery were viewed on their light table and frames were identified which are not in our data bank and, hence, will be ordered to augment our information on the lineament described above.

Reconnaissance field work has been done in southern Lincoln County, Nevada. Work was concentrated in the Delamar Mountains, Clover Mountains, Meadow Valley Mountains, Hiko Range, and the intervening valley areas. The field work was done to gain ground truth on a number of large fault systems in the area (some mapped by previous workers) and to investigate possible volcanic centers north of Kane Springs Wash which have expression in ERTS-1 color composite imagery produced by Argus Exploration Company. Storms, swollen streams, and poor road conditions inhibited field work in the higher parts of this area and field work will be concentrated in other parts of the test area until conditions improve in southern Lincoln County.

III. Conformance to Work Schedule:

Present Argus staffing limitations and time devoted to training of new personnel have temporarily slowed research progress. In addition, unusually severe weather conditions have hindered efficient field work even in low desert terrain because of flood damage to dirt roads. Much of the high desert terrain and all mountainous areas within the test site are still snow-bound.

Although data research and map compilations have proceeded satisfactorily, we have not completed all of the work planned for this report period.

IV. Analysis of Research Progress:

The hiring of additional scientific staff will aid progress in several phases of research. Although logistics in desert terrain are difficult to anticipate, we hope to be able to take advantage of the excellent weather expected in the next few months. Image enhancement and analysis have proceeded satisfactorily and we will continue experimentation with new processes and applications. Compilation of regional age date maps and known mineral deposit maps for the ERTS-1 test site is continuing on schedule. We have begun compilation of known geothermal sources and earthquake epicenter distribution maps.

V. Efforts to Achieve Reliability and Recommended Changes in Operation:

To better coordinate staff requirements and research task phasing, we have constructed a modified Pert network schedule for the ERTS-1 research program. To the extent possible, we have rescheduled field work to take advantage of favorable weather and terrain access. We are actively recruiting additional scientific personnel as required by research logistics.

VI. Significant Scientific Results:

Significant scientific results were reported in a paper "Regional Tectonic Control of Tertiary Mineralization and Recent Faulting in the Southern Basin-Range Province - An Application of ERTS-1 Data" presented at the ERTS-1 Symposium held March 5 through 9 at New Carrollton, Maryland. An abstract of this report was included in Type I Report, 15 March 1973.

VII. Funding Status:

As indicated in financial reports 533 Q and 533 M, dated 16 April 1973, proposed project funding will be sufficient to complete the contracted research program.

As was discussed in a telephone conversation with Mr. Ed Crump, additional burdens have been placed on our facilities and personnel to produce color composites which are not being secured from Goddard because of time limitations. Also, our research in photographic techniques has led to methods of color composite production which are highly successful. The estimates made in the proposal now appear to be inadequate to cover the costs of photographic supplies and Mr. MacGalliard's charges, as well as those which will develop in our own facility. It is suggested that transfer of funds from other categories of the estimate will be indicated in the future and discussions of this matter should be pursued as required.

VIII. Scientific Staff and Back-up Personnel:

The following personnel are presently assigned to the ERTS-1 investigation:

Scientific Staff

I. C. Bechtold, Principal Investigator
M. A. Liggett, Field Geologist and Co-investigator
J. F. Childs, Field Geologist

Technical Aids

R. L. Hutchens, Field and Office Assistant
J. Barth
P. Delaney (part time)

Back-up Personnel (covered in G & A)

Accountant
Secretary

Notice is being given to all associates that the office of Argus Exploration Company, including all of its activities, will be moved to the location of the parent organization, Cyprus Mines Corporation, on May 19, 1973. The new address and phone number will be:

Argus Exploration Company
555 South Flower, Ste. 3700
Los Angeles, CA 90071

(AC 213) 489-3700

IX. Work Planned for Next Reporting Period:

A. Field Reconnaissance:

Field work will concentrate in the low desert areas of the ERTS-1 test site to take advantage of the cool weather anticipated in the next two months. Imagery analysis and interpretation will be conducted along the Death Valley-Furnace Creek Fault zone and this will be followed by a program of field reconnaissance. The field team will study possible structural control of the Ubehebe volcanic center adjacent to the Furnace Creek Fault zone in northern Death Valley, and structural anomalies visible in ERTS imagery of Greenwater Valley and Fish Lake Valley, California and Nevada.

Analysis of ERTS-1 MSS and U-2 photography over the Wrightwood alluvial fan will be completed. This study will evaluate the use of ERTS data in discriminating the lithologic composition of the alluvial gravels.

A prominent east-west structural trend near Barstow, California, has been analyzed in ERTS-1 imagery and limited black and white X-15 photography. Field work is planned to identify the cause of the structural pattern. As snow cover conditions improve, field investigations of possible rhyolitic caldera centers in southern Lincoln County, Nevada will be resumed.

Further study of the northwest extension of the northwest-southeast lineament from west of Needles, California to Salome, Arizona is intended.

B. Image Enhancement and Analysis:

The image enhancement techniques developed for ERTS-1 MSS data will continue in coordination with Wally MacGallaird, Mac Gallaird Colorprints,

Incorporated. Additional research is planned on photographic edge enhancement processing. The application of laser Fourier transform analysis of the ERTS-1 MSS data will be investigated as a possible aid to structural pattern analysis.

C. Data Source Research:

Epicenter data for earthquakes occurring in the eastern California and southern Nevada areas, as programmed in the Chevron Research Laboratory computer at La Harbra, has been supplied by Dr. F. Sabins. Other sources of data will be combined with this to continue our correlation of epicenter locations and magnitudes with geologic structures in that area.

X. Authorized Reports and Publications:

As indicated in the March Type I Report, a paper entitled "Regional Tectonic Control of Tertiary Mineralization and Recent Faulting in the Southern Basin-Range Province - An Application of ERTS-1 Data" was presented at the ERTS-1 Symposium held March 5 through 9, 1973, at New Carrollton, Maryland. This meeting was attended by I. C. Bechtold, M. A. Liggett, and W. E. Hosken of Argus.

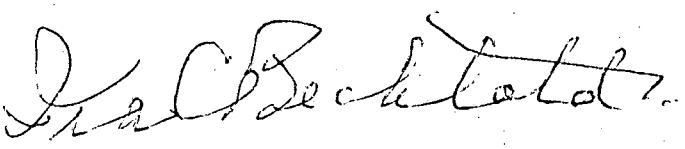
On April 17, 1973, a talk was presented from slides entitled "Orbital Remote Sensing for Mineral Resources Exploration" by I. C. Bechtold at Edwards Air Force Base, section of the American Institute of Aeronautics and Astronautics, at the request of Mr. C. Johnson, NASA Flight Research Center. This was essentially an expanded presentation of the same subject given at the National Meeting of AIAA, Washington, D. C., on January 8, 1973, by I. C. Bechtold and M. A. Liggett. (Abstract attached)

XI. Changes in Standing Order Form:

No changes have been necessary in our standing order form for this reporting period.

XII. NASA Data Request Forms:

Precision computer compatible tapes, image 1052-17490, bands 4, 5, 6 and 7, were received, returned, and replaced by bulk tapes which have been received.



Ira C. Bechtold
Principal Investigator

ABSTRACT

ORBITAL REMOTE SENSING FOR MINERAL RESOURCES EXPLORATION.

Ira. C. Bechtold, General Manager and Mark Liggett, Geologist
Argus Exploration Company, Newport Beach, California
AIAA, Washington, D.C. January 8, 1973

The synoptic view of Earth shown by Gemini, Apollo and ERTS-1 satellite imagery has revealed major geologic structures, which range in age from Precambrian to Recent. Many of these regional features were previously unknown by conventional mapping. These data are leading to new understandings of continental tectonics and regional structural controls of plutonism and volcanism which relate to ore deposition and geothermal energy sources. Additional remote sensing techniques being adapted for orbital use show promise in applications to geology and resource exploration. These include multifrequency SLAR, thermal IR and narrow-band multispectral scanner imagery, microwave radiometry, and magnetometry.

Presented by request of Mr. Samuel H. Hubbard, NASA Headquarters, Washington, D.C.

10